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Demographics and Vision Restrictions in Civilian Pilots: Clinical Implications

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16. Abstract

Background: The Federal Aviation Administration (FAA) permits airmen with certain medical conditions or diseases to be medically certified, provided that such action does not compromise aviation safety. The FAA Office of Aerospace Medicine helps guide policy decisions through the study of common medical pathologies, including visual disorders and the use of new ophthalmic devices and refractive procedures by airmen. To perform this function properly, an in-depth knowledge of the airman population is required. This study examined demographic statistics for the civil airman population, including vision pathologies, for the period 1976 to 2001 and their relevance to the clinical care of aviators by eyecare practitioners. **Methods:** Medical certification data were extracted from FAA publications and databases for all civil airmen who were active on December 31st of each year from 1976 to 2001. Frequency and medical restriction data were delineated into 5-year increments and analyzed to identify population trends for the 25-year study period. **Results:** Although the total number of airmen has decreased over the study period (-17%), the population of male and female airmen holding first-class medical certificates has grown by 119% and 1,241%, respectively. The percentage of airmen ≥ 40 years of age has increased by 17%, and the average age rose from 36.8 to 42.3 years of age. Additionally, the increase in near vision restrictions (13%) was more than double that of distant vision restrictions (6%) during the study period. As of 2001, 92% of all medical restrictions were vision related. **Conclusion:** The changing demographic profile of the civil airman population, which includes a growing number of first-class certificate holders, first-class female aviators, and the increasing maturity of the pilot population, may compound the challenge to eyecare practitioners tasked with advising aviators concerning the proper choice of refractive correction. To guide the clinician in recommending the most appropriate form of refractive correction, the unique aviation vision demands, ergonomic considerations, and environmental conditions experienced by the civilian pilot are discussed.

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Demographics and Vision Restrictions in Civilian Pilots: Clinical Implications

BACKGROUND

The origin of the Federal Aviation Administration (FAA) can be traced back to May 20, 1926, when then President Calvin Coolidge signed the Air Commerce Act into law. The act instructed the Secretary of Commerce to foster air commerce; designate and establish airways; establish, operate, and maintain aids to air navigation; arrange for research and development to improve such aids; license pilots; issue airworthiness certificates for aircraft and major aircraft components; and investigate accidents. On April 6, 1927, William P. MacCracken, Jr., Assistant Secretary of Commerce for Aeronautics, received Pilot License No. 1, thus becoming the first person to obtain a pilot license from a civilian agency of the U.S. Government.

Since then civil aviation has become a major commercial and technological industry that has a substantial impact on the United States economy. Based on the most recent study by Wilber Smith Associates, which examined the civil aviation's economic impact for the year 1998, commercial and general aviation contributed $976 billion to the U.S. economy and generated 10.9 million jobs with annual earnings in excess of $278 billion (1). To sustain the current level of usage and allow for future expansion of the National Airspace System (NAS), the FAA permits airmen with certain medical conditions or diseases to obtain aeromedical certificates, provided that such action does not compromise aviation safety. The Office of Aerospace Medicine helps guide policy decisions through the study of common medical pathologies, including visual disorders and the use of new ophthalmic devices and refractive procedures by airmen in the aviation environment.

The FAA medical certification process requires that each airman hold a current medical certificate of the appropriate class. In the U.S., there are approximately 5,000 aviation medical examiners (AMEs) that are responsible for the medical examinations of more than 650,000 pilots. First-time pilot applicants and those seeking re-certification may apply for one of three classes of medical certificate. First-class certificate holders include air transport pilots, who often fly large, sophisticated passenger aircraft. Second-class certificate holders include commercial pilots, who may fly cargo aircraft, commuter aircraft with 30 passengers or less, or provide aero-application services, i.e., "crop dusters." Third-class certificate holders primarily fly for pleasure in light, privately owned aircraft.

Aeromedical examinations are periodically administered and require the applicant to meet minimum medical standards needed for a particular category or class of flight. For first-class certification, medical examinations are performed every 6 months, second-class every 12 months, and third-class pilots must be examined every 36 months if they are < 40 years of age and every 24 months if they are ≥ 40 years of age (2). Medical standards for each class of medical certificate are detailed in Title 14 of the Code of Federal Regulations (CFR) Part 67, §67.103, §67.203, §67.303 (3). Vision standards for the three classifications of pilot certificates are summarized in Table 1.

Medical certification criteria have changed through the years in response to advances in medical knowledge, treatments, and aviation technology. Aeromedical research provides substantive data to validate current medical certification criteria or identify the need to change existing practices to enhance aviation safety and better serve the civil aviator and the flying public. The Aerospace Medical Certification Division of the Civil Aerospace Medical Institute (CAMI), located in Oklahoma City, OK, is the FAA's central screening facility and repository for the collection, processing, adjudication, investigation, and analysis of medical data generated by the aeromedical certification and related regulatory programs. Research activities performed at CAMI include identifying changes in the aerospace and medical industries and conducting investigations that provide relevant data required to guide the policy-making decisions that advance aviation safety.

CAMI's Vision Research Team conducts ongoing research concerning current and anticipated vision problems associated with aviation activities. Research includes supporting the airman certification process and evaluating the effects of aging and chronic disease as they relate to the visual requirements of the aviation environment. To perform this function properly, an in-depth knowledge of the current airman population demographics is required. This retrospective epidemiological study examined demographic statistics for the civil airman population, including vision pathologies, for the period 1976 to 2001, by age, gender, and class of medical certification and discusses their relevance to the clinical care of aviators by eyecare practitioners.

Table 1: A summary of FAA vision standards.

Restriction	First-Class	Second-Class	Third-Class
Distant Vision	Distant visual acuity of 20/20 or better in each eye separately, with or without corrective lenses. If corrective lenses (spectacles or contact lenses) are necessary for 20/20 vision, the person may be eligible only on the condition that corrective lenses are worn while exercising the privileges of an airman certificate.		Distant visual acuity of 20/40 or better in each eye separately, with or without corrective lenses. If corrective lenses (spectacles or contact lenses) are necessary for 20/40 vision, the person may be eligible only on the condition that corrective lenses are worn while exercising the privileges of an airman certificate.
Near Vision	Near vision of 20/40 or better, Snellen equivalent, at 16 inches in each eye separately, with or without corrective lenses.		
Intermediate Vision	If ≥ 50 years of age, vision of 20/40 or better, Snellen equivalent, at 32 inches in each eye separately, with or without corrective lenses.		No Standard.
Heterophoria	Bifoveal fixation and vergence-phoria relationship sufficient to prevent a break in fusion under conditions that may reasonably be expected to occur in performing airman duties[1].		No Standard.
Color	Ability to perceive those colors necessary for the safe performance of airman duties.		
Field of Vision	Normal fields of vision.		Same as Pathology Standard below.
Pathology	No acute or chronic pathological condition of either eye or adnexa that interferes with the proper function of an eye, that may reasonably be expected to progress to that degree, or that may reasonably be expected to be aggravated by flying.		

[1]If more than 1 prism diopter of hyperphoria, 6 prism diopters of esophoria, or 6 prism diopters of exophoria are exceeded, the Federal Air Surgeon may require the applicant to be examined by a qualified eye specialist to determine if there is bifoveal fixation and an adequate vergence-phoria relationship. The applicant, if otherwise eligible, is issued a medical certificate pending the results of the examination (2).

METHODS

Demographic statistics and medical restriction data were collected for all civilian airmen who were active on December 31st of each study year for the period 1976 to 2001. These data were extracted from the Aeromedical Certification Statistical Handbook, published annually by CAMI's Aerospace Medical Certification Division (4) and from data collected by CAMI's Bioinformatics Team. (Note: Publication of the Aeromedical Certification Statistical Handbook was suspended after 1998.) Frequency and medical restriction data were examined for anomalies, which were corrected or deleted. The data were then delineated into 5-year increments and analyzed to identify population trends for the 25-year study period. Frequency counts, average age, and percentage of restrictions were calculated for various stratifications, which included class of medical certification, gender, and age category (< 40 and ≥ 40 years of age). Although the precise definition of some vision restrictions changed slightly during the study period, for this investigation the following definitions were applied:

1. Must have available glasses for near vision.
2. Must wear corrective lenses.
3. Must wear corrective lenses for near and distant vision.
4. Must wear lenses for distant and possess glasses for near vision.
5. Must wear corrective lenses and possess glasses for near and intermediate vision.

6. Holder shall possess glasses for near and intermediate vision.
7. Must wear prismatic correction.
8. Must wear corrective lenses: extra pair must be available.
9. Not valid for night flying or by color signal control (color vision).
10. Not valid for night flying (glaucoma).

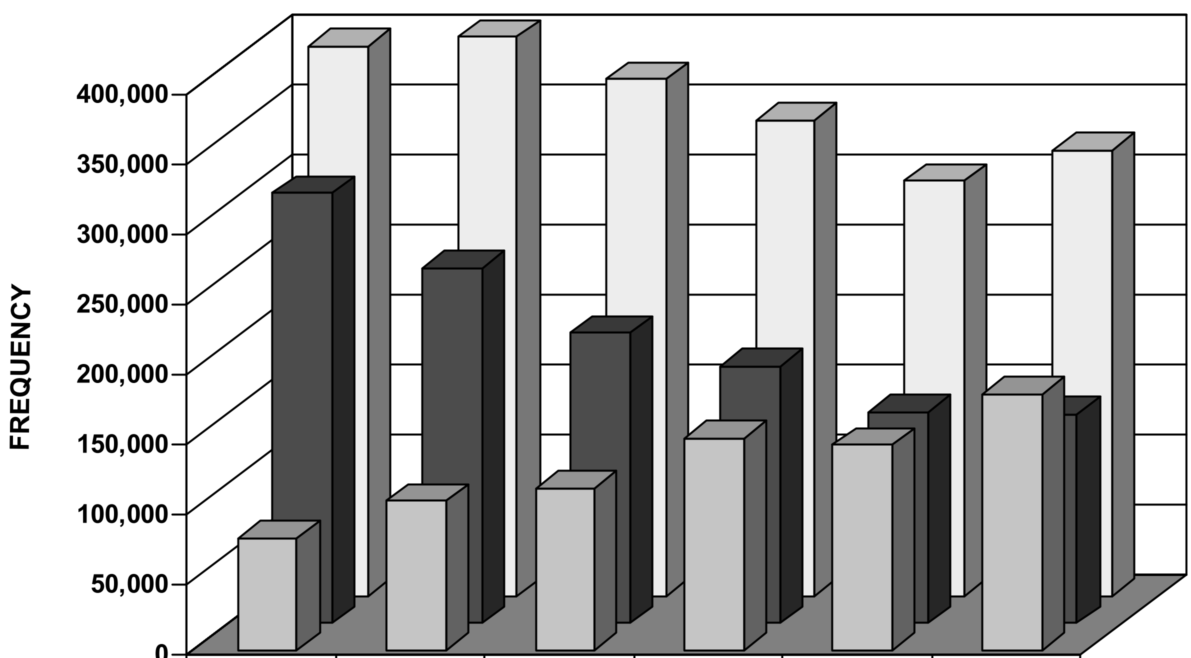
The vision restrictions were grouped into general categories resulting in some overlap within these categories. The vision restrictions listed above were assigned to categories as indicated by their item numbers in the following manner:

Defective Distance Vision (DDV) = 2-5,8
Defective Near Vision (DNV) = 1,3-6
Defective Intermediate Vision (DIV) = 5,6
Defective Vision (DV) = 1-10

RESULTS

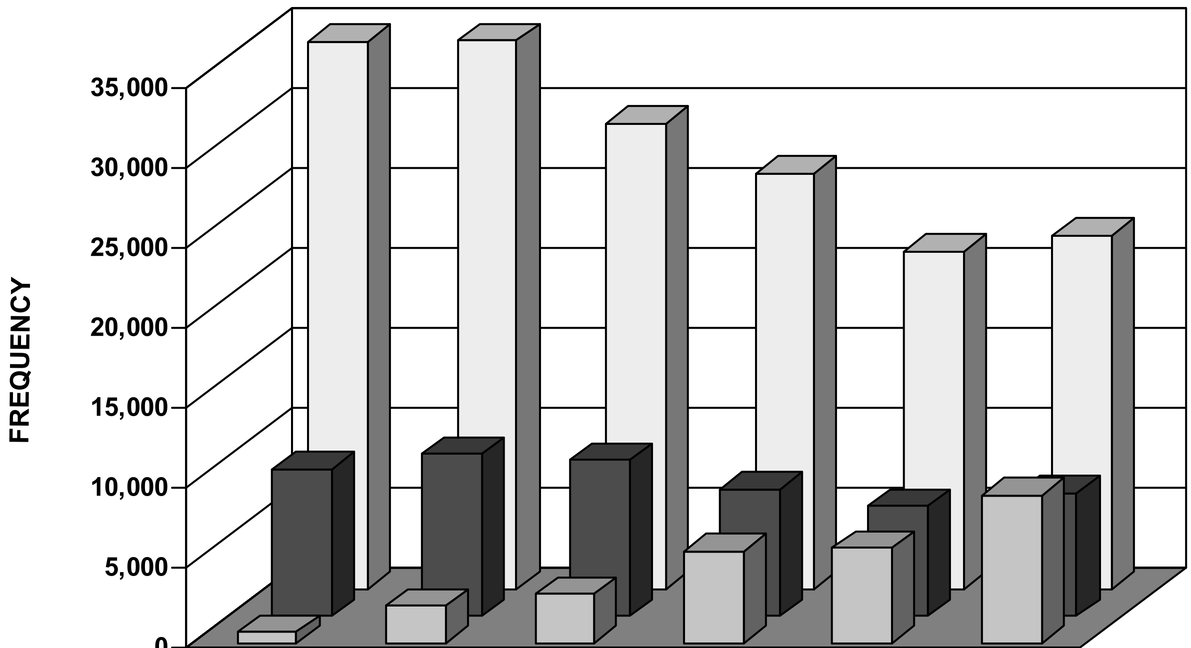
The total airman population in 2001 (650,146 airmen) had decreased by approximately 17% from a total of 780,408 airmen in 1976. For the same period, second- and third-class airman populations decreased by 52% (from 307,364 to 149,029 airmen) and 19% (from 393,246 to 318,382 airmen), respectively, while the first-class airman population increased by 129% (from 79,798 to 182,735 airmen; see Figure 1).

The total female airman population decreased by 11% from 1976 (44,128 airmen) to 2001 (39,098 airmen). However, the first-class female population exhibited the largest relative gain (13.4 times or 1,241%) in frequency for the period with an increase from 690 pilots in 1976 to 9,255 in 2001 (see Figure 2). During the study period, the total male airman population decreased by 17% overall, while first-class male medical certificate holders increased (119%) from 79,108 airmen to 173,480 (see Figure 3). The ratio of males to females in the total airman population decreased from 17:1 in 1976 to 16:1 in 2001. A similar comparison of the first-class airman population showed a significant relative increase in female aviators from a 115:1 male to female ratio in 1976 to a 19:1 ratio in 2001.



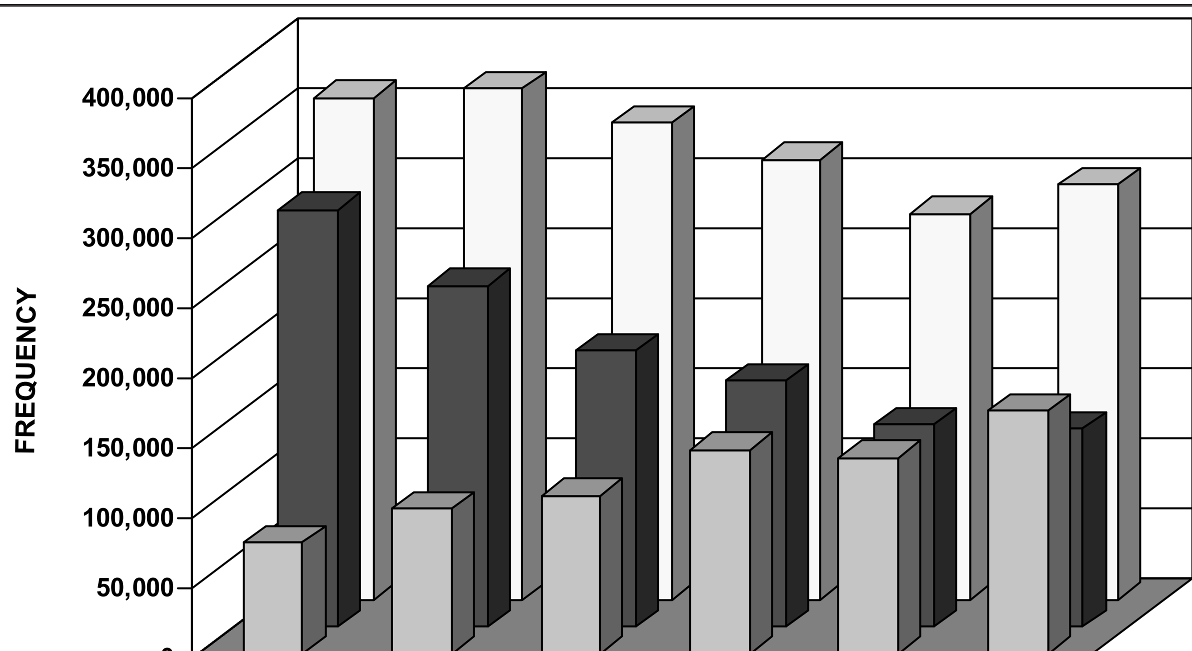
	1976	1981	1986	1991	1996	2001
CLASS I	79,798	105,987	115,808	151,350	146,006	182,735
CLASS II	307,364	253,611	207,255	183,374	150,823	149,029
CLASS III	393,246	399,518	369,695	340,343	296,899	318,382

Figure 1: Total Airman Population by Class



	1976	1981	1986	1991	1996	2001
CLASS I	690	2,313	3,049	5,716	5,958	9,255
CLASS II	9,197	10,130	9,740	7,933	6,884	7,704
CLASS III	34,241	34,339	29,126	26,025	21,140	22,139

Figure 2: Total Female Airman Population by Class

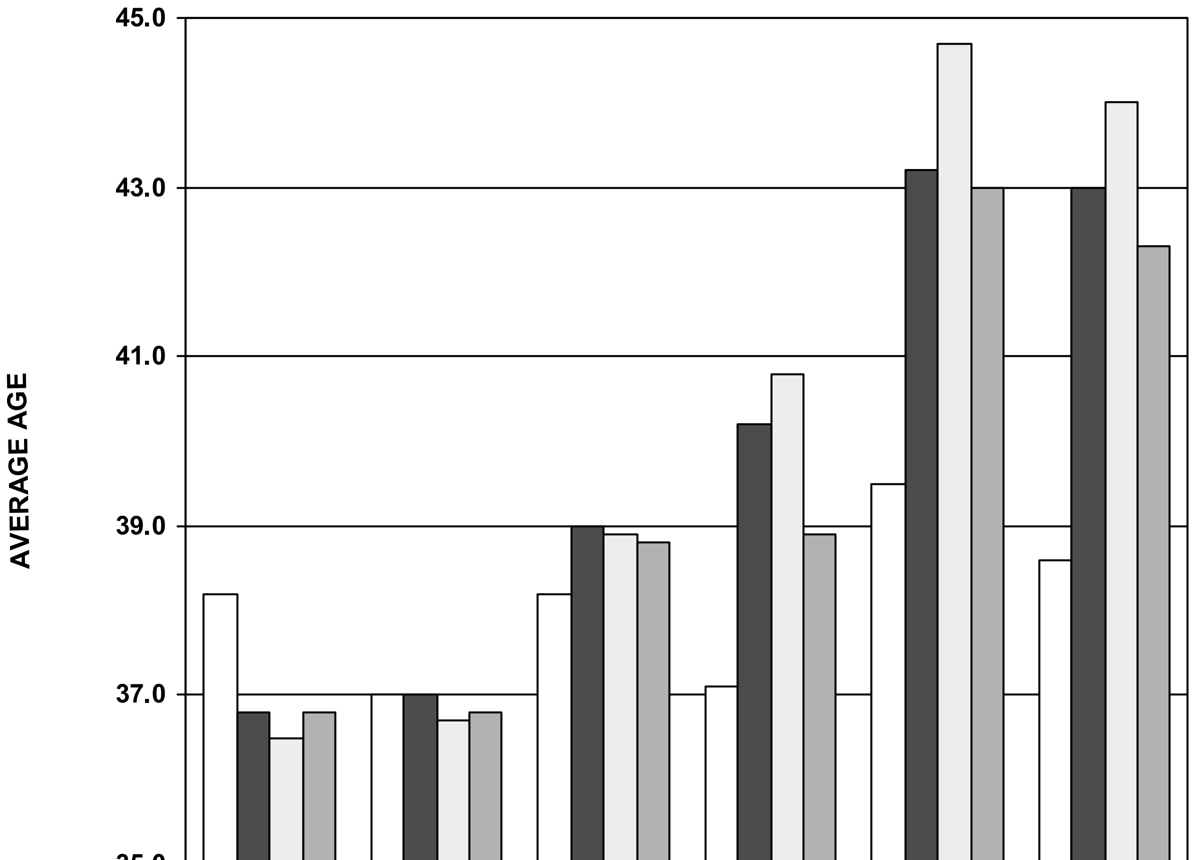


	1976	1981	1986	1991	1996	2001
CLASS I	79,108	103,674	112,759	145,634	140,048	173,480
CLASS II	298,167	243,481	197,515	175,441	143,939	141,325
CLASS III	359,005	365,179	340,569	314,318	275,759	296,243

Figure 3: Total Male Airman Population by Class

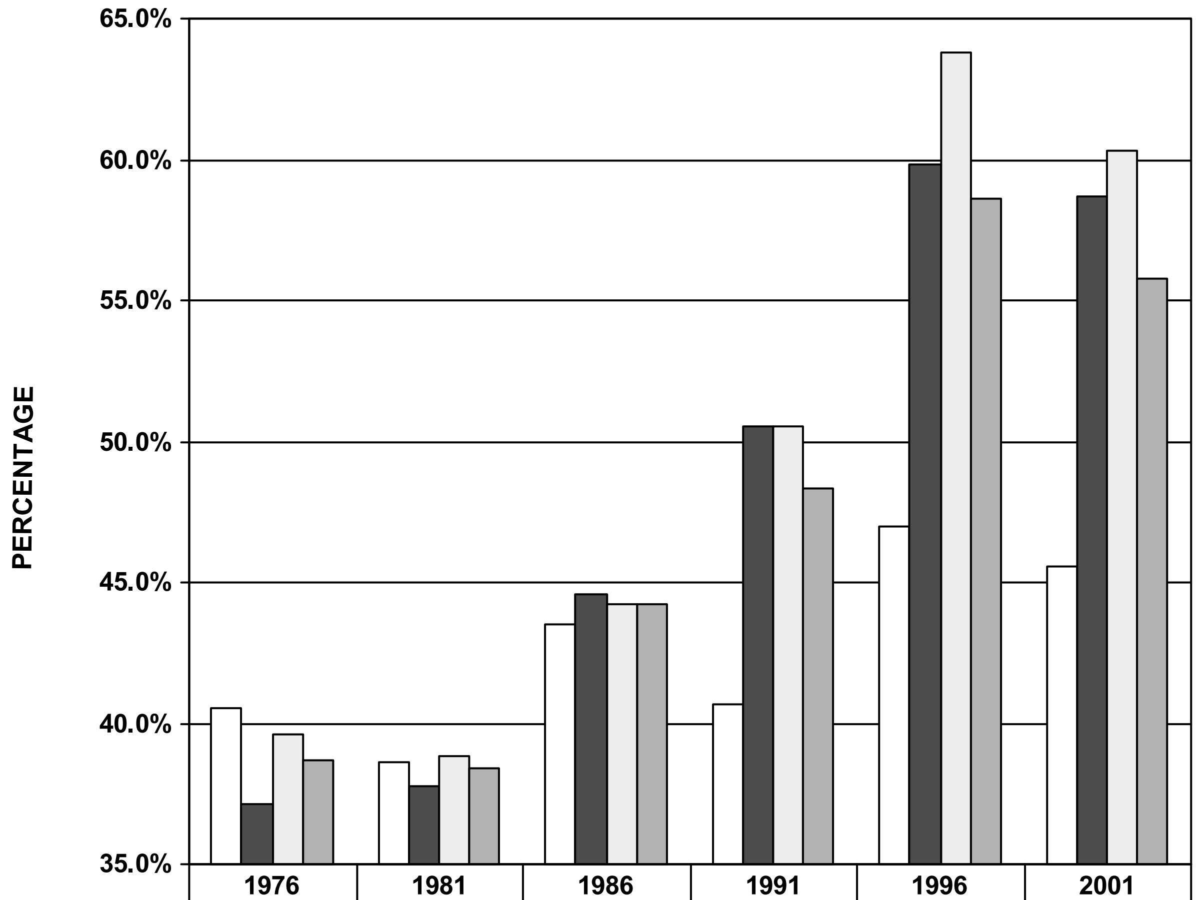
In the total civil airman population, the average age increased from 36.8 to 42.3 years of age from 1976 to 2001 (see Figure 4). This trend was also reflected by an increase in the percentage of airmen ≥ 40 years of age from 38.7% in 1976 to 55.8% in 2001 (see Figure 5). By class of medical certification, the percentage of airmen ≥ 40 years of age in the first-class airman population increased from 40.5% to 45.6%, second-class from 37.1% to 58.7%, and third-class from 39.6% to 60.3% during the study period.

From 1976 to 2001, there was a 10.1% increase in the number of medical restrictions held by civil airmen (from 44.4% to 54.5%), which included an 8.6% increase in the number of restrictions associated with visual conditions (see Figure 6). The percentage of airmen in the total airman population with defective distance vision (DDV) increased from 32.6% in 1976 to 38.8% in 2001. For the same period, the percentage of those with defective near vision (DNV) increased from 8.1% to 21.3%. This represents a 13.1% difference in the number of DNV restrictions, compared with 6.2% for DDV, from 1976 to 2001. In addition, the new defective intermediate vision (DIV) restriction category, introduced September 16, 1996, grew from approximately 0.1% to 4% in the last 5 years of this study.



	1976	1981	1986	1991	1996	2001
□ CLASS I	38.2	37.0	38.2	37.1	39.5	38.6
■ CLASS II	36.8	37.0	39.0	40.2	43.2	43.0
□ CLASS III	36.5	36.7	38.9	40.8	44.7	44.0
■ TOTAL	36.8	36.8	38.8	38.9	43.0	42.3

Figure 4: Total Airman Average Age by Class



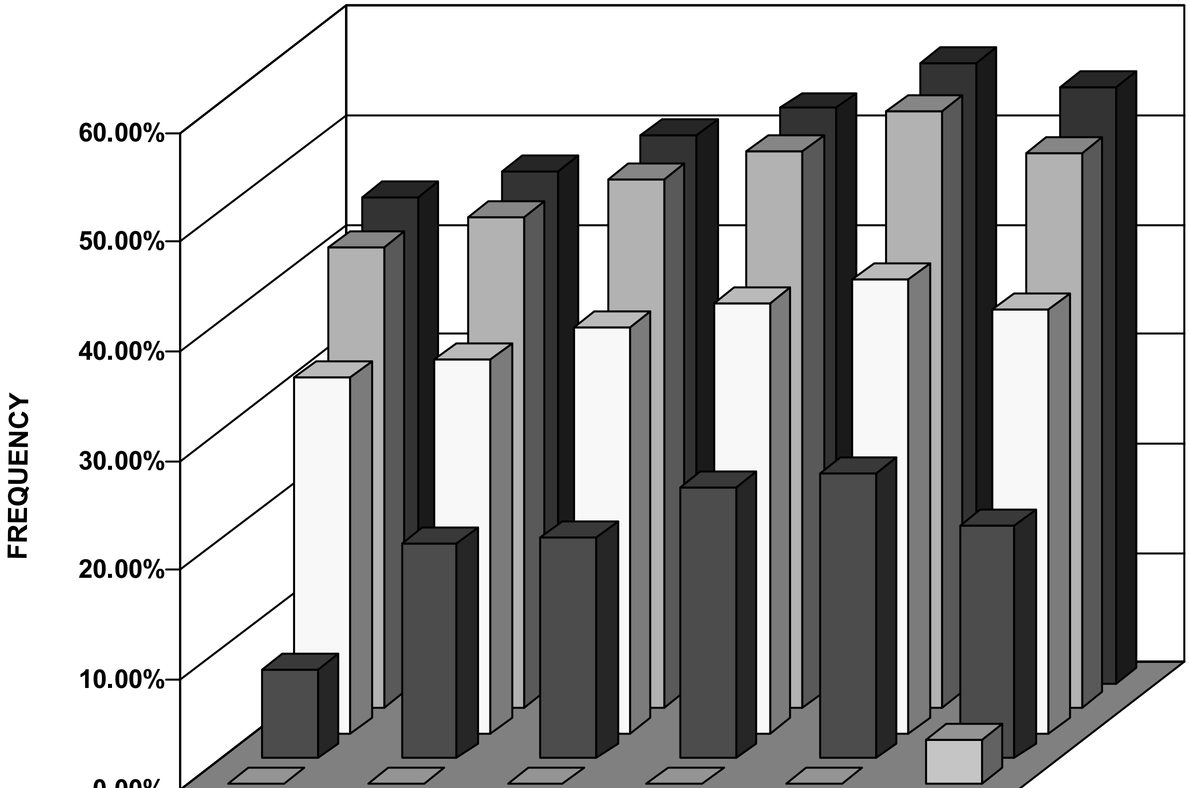
	1976	1981	1986	1991	1996	2001
□ CLASS I	40.5%	38.6%	43.5%	40.7%	47.0%	45.6%
■ CLASS II	37.1%	37.8%	44.6%	50.5%	59.8%	58.7%
□ CLASS III	39.6%	38.8%	44.2%	50.5%	63.8%	60.3%
■ TOTAL	38.7%	38.4%	44.2%	48.3%	58.6%	55.8%

Figure 5: Percentage of Airmen ≥ 40 Years of Age

DISCUSSION

For the study period, there was an overall decline in the total number of civil airmen (-17%) despite a relative increase of 8.7% during the last 5 years, from 593,728 airmen in 1996 to 650,146 airmen in 2001. This increase was primarily due to the influx of first- and third-class pilots during this 5-year period. However, the first-class airman population sustained steady growth throughout the entire 25-year study period (i.e., an increase of 102,937 airmen or 129%). This increase is indicative of the growth in air-carrier activity during the study period. The 52% decrease in second-class airmen for the study period may reflect changes in commercial and commuter aviation activities. The 1,241% increase in female pilots within the ranks of first-class medical certificate holders may be attributed to the socioeconomic and attitude changes that have occurred in the United States and other countries during this period that encouraged women to seek advancement in traditionally male-dominated vocations. While parity within the total civil airman population may not be realized for some time, the dramatic decrease in the ratio of males to females (from 115:1 to 19:1) for first-class airmen during the study period demonstrates significant movement in this direction.

According to the 2000 census, people born in the U.S. during the early years of the "baby boom" (1946 through 1950) fueled a 55% increase in the 50- to 54-year-old age group, the largest percentage growth between 1990 and 2000 of any 5-year age group (5). The second fastest growing group was 45- to 49-year-olds, which registered a 45% increase. This general trend in the U.S. population is reflected in the increase found for the percentage of civil airmen ≥ 40 (from 38.7% to 55.8%) and the



	1976	1981	1986	1991	1996	2001
DIV	0.00%	0.00%	0.00%	0.00%	0.08%	4.01%
DNV	8.12%	19.64%	20.23%	24.75%	26.07%	21.26%
DDV	32.59%	34.26%	37.10%	39.40%	41.48%	38.81%
VISUAL	42.09%	44.95%	48.39%	51.00%	54.57%	50.68%
MEDICAL	44.40%	46.73%	50.05%	52.56%	56.59%	54.54%

Figure 6: Percentage of Visual and Medical Restrictions by Class

increase in average age (from 36.8 to 42.3 years of age) observed during the 25-year period of the study. In addition, with the continued aging of military-trained pilots who became civil aviators after World War II, and the Korean and Vietnam Wars, it is understandable that the civilian airman population is maturing. Other factors such as the high cost of flight training, aircraft rental and purchase, aviation fuel, and related expenses may be keeping all but the most resourceful younger pilots from entering the civil airman ranks.

Within the civil airman population, first-class pilots were younger on average (38.6 years) and the average age did not increase as quickly as their second- and third-class counterparts during the study period (i.e., average age increased by 0.4 years, 6.2 years, and 7.5 years for first-, second-, and third-class airmen, respectively). The FAA's mandatory retirement rule (i.e., Title 14 of the CFR, Part 121, §121.383 (c) [6]) for air transport pilots at 60 years of age may have influenced the minimal increase observed in the average age of first-class airmen. As a result, these airmen may be less motivated to seek a first-class certificate that must be renewed every 6 months. Interestingly, a first-class airman was older than the average airman in 1976 (38.2 vs. 36.8 years of age) but became younger than the average airman by 2001 (38.6 vs. 42.3 years of age). In 2001, the average age of male airmen was 42.6 years, compared with 36.2 years for female aviators. For the study period, male aviators aged an average of 5.5 years, while women aviators aged only 4.0 years. This suggests that either a disproportionately larger number of young females entered the civilian airman population during the study period or female aviators did not continue to fly as long as their male counterparts as they aged.

The increasing number of females in the first-class civil airman population where vision standards are more stringent could present a unique challenge for the eyecare

practitioner. Females often have specific vision problems that can be exacerbated in the aviation environment. Younger females may experience shifts in refractive error due to pregnancy or the use of oral contraceptives (7), while older females may experience problems with their vision due to hormonal shifts associated with menopause and/or the use of hormone supplements (8,9,10). These problems can include not only a shift in their refractive error, but also the increased potential for dry-eye and glare disability (11). Poor acuity, dry-eye, and glare sensitivity problems could compound difficulties inherent in the aviation environment. For example, pilots are often required to "see and avoid" other aircraft, obstacles, or terrain under conditions of low humidity and glare from the sun or artificial sources. Furthermore, the use of contact lenses and refractive surgical correction may aggravate dry-eye and glare sensitivity problems and increase the probability of eye pathologies for women using cosmetic products such as mascara and eyeliner (12,13,14).

The increase in age found in the total airman population may also add to the problem of providing optimal correction for a pilot in flight. Vision problems become more prevalent as people age and clinical studies now estimate that, by 65 years of age, one person in three will have some form of visually debilitating eye disease (15). Problems with cataract, low-luminance acuity (16,17), disability glare (18), contrast sensitivity (19,20), color vision (21), stereo-acuity (22), and recovery from glare are more common among seniors (23). In addition, the increased reliance on reading glasses and intermediate vision correction due to the onset of presbyopia around 40 years of age is a major consideration when prescribing for the older aviator. It has been estimated that the presbyopic addition increases in patients from ages 40 to 50 years at an average rate of approximately 0.25 diopters every 2 years (24). Therefore, older pilots should be examined more often to ensure that they are optimally corrected for the demands placed on their vision while conducting flight operations.

As sophisticated instrumentation that employ multifunction liquid crystal (LCD) and cathode-ray tube (CRT) displays become more prominent (i.e., glass cockpit technology), even in smaller general aviation aircraft, the visual demand on pilots will continue to evolve and create new challenges for eyecare providers. A pilot should not only see well at distance, but must also read instrument panels above and below the line of sight as well as charts and manifests while flying. Pilots with presbyopia should record the distances to critical instruments and provide that information to the eyecare practitioner so that task-specific lenses can be prescribed for use in the cockpit (see Figure 7). In addition, communication and protective breathing equipment should be checked for compatibility with ophthalmic devices and steps should be taken to correct any problems before an emergency situation develops. Underscoring the importance of proper refractive correction, a recent FAA study found the lack of use, misuse, and the application of inappropriate forms of ophthalmic correction contributed to a number of aviation accidents and incidents (25).

For airmen who choose to wear contact lenses in the aviation environment, low barometric pressure and relative humidity may affect contact lens comfort. This may be especially troublesome for airmen who are already experiencing problems with age- or gender-related dry-eye conditions (11,26). In addition, common side effects such as dry eyes, glare disability, and loss of contrast sensitivity may become more problematic for airmen

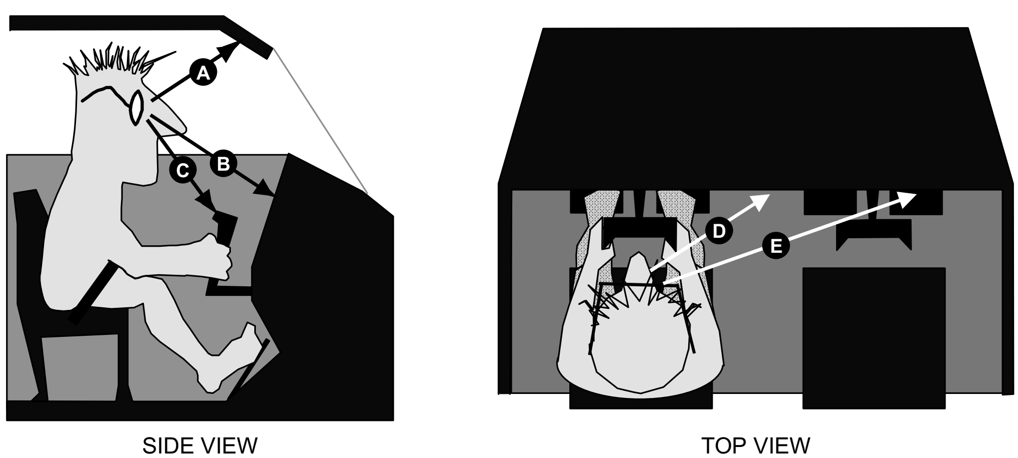


Figure 7: Presbyopic pilots should measure distances to critical instruments in the cockpit.

who opt for laser refractive surgery as an alternative to a traditional ophthalmic device (27,28,29). (Note: A 2000 study reported that females had a higher prevalence for refractive surgery in all three classes of aeromedical certification compared to males [30]).

Since vision restrictions represent more than 90% of all medical restrictions assigned to civilian airmen, it is no surprise that vision problems are the single most common reason for denial of a medical certificate. The pilot and his or her eyecare practitioner should be aware of the vision requirements for the class of certification sought. Often, it may be necessary to update a corrective device prior to an aeromedical re-certification examination. Troublesome visual situations, such as glare sensitivity or visual aberrations during nighttime operation, should be discussed. Since it is not always possible for the eyecare practitioner to know what questions to ask, especially when he/she is not a pilot, the patient is ultimately responsible for providing the clinician with the information necessary to ensure that he/she is properly corrected. Being familiar with the visual demands that are a common part of the aviation environment and problems encountered while in flight will allow the eyecare practitioner to make appropriate recommendations concerning the type of ophthalmic correction that will provide the best visual performance for a particular ophthalmic condition.

In summary, the demographics of the civil airman population changed considerably during the study period. Ensuring that aviators maintain appropriate refractive correction while conducting flight operations is essential to aviation safety. This challenge has become increasingly complex due to the proliferation of refractive devices and procedures in recent years, in addition to the advances in aviation technology and avionics that have placed new demands on a pilot's vision. The changing demographic profile, particularly for first-class certificate holders, and increasing maturity of the airman population, will compound the challenge to eyecare practitioners tasked with advising aviators concerning the proper choice of refractive correction for their particular ophthalmic condition and aviation activities. With a working knowledge of the unique vision demands, ergonomic considerations, and environmental conditions experienced by the civilian pilot, the clinician can advance aviation safety by recommending the most appropriate form of refractive correction.

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